



# **Psychological Barriers in the Latin America's Stock Indices**

Franklin Pedro Lemos Carneiro da Silva

[110401171@fep.up.pt](mailto:110401171@fep.up.pt)

**Dissertation**

**Master in Finance**

**Supervisor:** Júlio Fernando Seara Sequeira da Mota Lobão, Phd

**Co-Supervisor:** Natércia Silva Fortuna, Phd

School of Economics and Management of the University of Porto, FEP

**September 2017**

## **Bibliographical Note**

Franklin Silva was born on July 29, 1993, in Porto, Portugal. His interest in the financial markets world deepened when he was 17 years old. He got in touch for the very first time with the book “Ganhar em Bolsa” written by Fernando Braga de Matos. At the time, he already had an extensive desire to deeply understand the field of Economics which was showed by enrolling in the Economics course in high school before proceeding his studies in the Bachelor of Economics at School of Economics and Management of the University of Porto, FEP.

In 2015, he joined the Master in Finance at the same faculty as in the Bachelor, successfully concluding subjects of his appeal such as Markets and Financial Investments, Corporate Finance and International Finance. In the same year, he entered in the FEP Finance Club as a Market Researcher inside the Department of Financial Markets which he later became the director. Since then, his responsibilities were organising business trips, conferences, meetings within each sub-department and ensure the deadline commitment in the daily, weekly and monthly reports.

During the Master, he also concluded an Erasmus program at Kozminski University in Warsaw, Poland. While in there, he participated in the FEP Trading Cup where he finished in 1<sup>st</sup> place with a portfolio return of 127%. During the game, he realised how often some numbers seemed to appear more often than others during the daily trading activities giving him an extra incentive to further study that phenomenon.

## **Acknowledgments**

*“An investment in knowledge pays the best interest”,*

*Benjamin Franklin*

I will take this awe-inspiring, and unique opportunity to thank all the people involved not only during my dissertation preparation but, most importantly, in my whole academic and personal life.

My first acknowledge goes to my advisors, Professor Júlio Lobão and Professor Natércia Fortuna, for the commitment demonstrated since the beginning of my project. The wisdom transmitted, the suggestions and comments given and the care which both showed were priceless and extremely relevant to me. Furthermore, I thank, once again, Professor Júlio Lobão for drawing my attention on the crucial aspects of behavioural finance which, ultimately, led me to perform this dissertation.

I also would like to express my gratitude to all the previous professors I encountered during my education process who were fundamental to shape my bases to achieve this high level of instruction.

Likewise, I want to show my gratefulness to all my friends which are a constant presence in my life. Their opinions in most of my decisions were crucial to better judge future paths.

My last and most significant “thank you!” goes to my family. The support in whole my life since I was born until this moment has been marked by excellent moments and not so good ones. Nonetheless, at the end of the day, they are always present. That feeling of love, affection and protection, no words can describe it. The valuable investment in my education with sacrifice during all this time will be worth it and I am eternally grateful.

## **Abstract**

The question regarding the existence of psychological barriers is often answered with a “yes”. From market players’ to journalists’ viewpoints, this mass psychology effect is an obvious fact, as it is daily noticeable in the markets. Nonetheless, the conventional finance wisdom holds the conviction that this kind of anomalies is too small or too short lived to be exploitable.

This study examines for the first time, to the extent of our best knowledge, the existence of psychological barriers in the Latin America’s stock indices. Due to its relevance, available data and market size, we chose to analyse the major stock market index of each of the eight following countries: Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru, and Venezuela. Thus, the topic gains relevance as the literature lacks evidence in this geographical area. We collect a comprehensive set of data spanning from a variety of dates depending on each index available information till December 31<sup>st</sup>, 2015. In order to test the existence of psychological barriers, we performed a uniformity test, a barrier proximity and hump tests as well as conditional test and conditional differences tests.

The primary findings of the study suggest the existence of psychological barriers in the main indices of each of these countries: Argentina, Mexico, Panama and Peru. On the other hand, Brazil, Colombia and Venezuela show inconclusive results. In Chile, there is no evidence of barriers at all. Thus, our results seem to open the possibility of using an investment strategy based on this phenomena.

**Key words:** Psychological barriers, stock indices, round numbers, Latin America

**JEL-Codes:** G11, G12, G14, G15

## **Sumário**

A questão acerca da existência de barreiras psicológicas é, na maioria das vezes, respondida com um “sim”. Desde o ponto de vista de intervenientes diretos no mercado a jornalistas, este efeito psicológico em massa é um facto óbvio, tendo em conta as movimentações do mercado. Contudo, a teoria financeira convencional mantém a sua convicção de que este tipo de anomalias é demasiado pequeno ou de durabilidade reduzida para ser explorado.

Este estudo examina pela primeira vez, segundo o nosso conhecimento até ao momento, a existência de barreiras psicológicas nos índices de ações da América Latina. Pela sua relevância, informação disponível e dimensão do mercado, a análise incidiu sobre os principais índices de ações de cada um dos seguintes países: Argentina, Brasil, Chile, Colômbia, México, Panamá, Peru e Venezuela. Assim, este tópico ganha ainda mais importância pela literatura académica não apresentar nenhum estudo nesta área geográfica. A recolha de dados para cada um dos índices em estudo levou a que a data de início de análise variasse de acordo com os dados obtidos para cada um deles e a pesquisa terminasse a 31 de Dezembro de 2015. De modo a respondermos à nossa questão de investigação, decidimos implementar um teste de uniformidade, testes de barreiras de proximidade e de toda a distribuição como um todo, como também testes condicionais e das diferenças entre os mesmos testes.

Os principais resultados obtidos sugerem a existência de barreiras psicológicas nos índices principais de cada um dos seguintes países: Argentina, México, Panamá e Peru. Por outro lado, Brasil, Colômbia e Venezuela apresentam resultados inconclusivos. No Chile, não existe evidência de barreiras em nenhum nível considerado. Assim, os nossos resultados deixam em aberto a possibilidade do uso de uma estratégia de investimento baseada neste fenómeno.

**Palavras-chave:** Barreiras psicológicas, índices de ações, números redondos, América Latina

**Códigos JEL:** G11, G12, G14, G15

## **Table of contents**

Bibliographical Note .....	i
Acknowledgments .....	ii
Abstract / Sumário .....	iii/iv
<b>1. Introduction.....</b>	<b>1</b>
<b>2. Literature Review .....</b>	<b>4</b>
2.1 Market Inefficiency .....	4
2.2 Psychological Barriers and Other Related Effects/Events .....	5
2.2.1 Psychological Barriers .....	5
2.2.2 Bandwagon Effect .....	5
2.2.3 Clustering .....	6
2.2.4 Media .....	6
2.3 Psychological Barriers' Reasons .....	6
2.3.1 Anchoring and Roundophobia .....	7
2.3.2 Aspiration Levels.....	7
2.3.3 Odd Pricing .....	8
2.3.4 Cost Efficiency .....	9
2.3.5 Price Clustering .....	9
2.4 Empirical Studies .....	9
2.4.1 Stock Indices and Individual Stocks.....	10
2.4.2 Bonds .....	11
2.4.3 Foreign Exchange .....	11
2.4.4 Futures and Options .....	12
2.4.5 Commodities .....	13
<b>3. Data and Methodology .....</b>	<b>15</b>
3.1 Data .....	15

3.2 Methodology.....	17
3.2.1 Definition of Barriers.....	18
3.2.2 <i>M</i> -values.....	18
3.2.3 Uniformity Test.....	20
3.2.4 Barrier Tests.....	21
3.2.5 Conditional Effects Tests.....	22
<b>4. Empirical Study.....</b>	<b>24</b>
4.1 Uniformity Test.....	24
4.2 Barrier Tests.....	25
4.2.1 Barrier Proximity Test.....	25
4.2.2 Barrier Hump Test.....	32
4.3 Conditional Effects.....	34
4.3.1 Conditional Effects Difference Tests.....	38
<b>5. Conclusion.....</b>	<b>42</b>
<b>References.....</b>	<b>44</b>

## **List of Tables**

Table 1 – Data Explored in the Study .....	15
Table 2 – Summary Statistics on Latin America's Indices Data Series .....	17
Table 3 – Kolmogorov-Smirnov test for uniformity .....	25
Table 4 – Barrier Proximity Test: Strict Barrier (00).....	27
Table 5 – Barrier Proximity Test: 98-02 Barrier.....	28
Table 6 – Barrier Proximity Test: 95-05 Barrier.....	29
Table 7 – Barrier Proximity Test: 90-10 Barrier.....	30
Table 8 – Barrier Proximity Test: 75-25 Barrier.....	31
Table 9 – Barrier Hump Test .....	33
Table 10 – Conditional Effects Summary 5 days: Return and Variation Equation – GARCH (1;1).....	35
Table 11 – Conditional Effects Summary 10 days: Return and Variation Equation – GARCH (1;1).....	37
Table 12 – Conditional Difference Tests for Conditional Moments: 5 days.....	40
Table 13 – Conditional Difference Tests for Conditional Moments: 10 days.....	41



## **1. Introduction**

On a daily basis, the financial world pays attention to irregular moves that the traditional finance theory does not predict. Psychological barriers are considered to be one of them, and it seems to have a higher effect on the markets as technical analysis appears to be more and more vastly used. This behavioural phenomenon manifests by the difficulty in surpassing a barrier to a different level, usually at round ending numbers. For some reasons, not explained by fundamental values, investors tend to overlook to round numbers as being more relevant than non-round numbers.

Interestingly, also the financial media highlights those events:

- “Chile's blue-chip IPSA stock index jumped more than 1.5 percent on Tuesday (...), nearing the psychological barrier of 5,000 points” – Reuters (2010)
- “The Bovespa is defending the 60,000 point level, that's a major psychological barrier for the market. It would require some stronger negative reason for this break (...)" – Reuters (2012)

Since we did not find any prior research in this geographical area, we strongly believe that this is the first study examining the existence of psychological barriers in the Latin America's stock indices. Due to its importance, available data and market size, we chose to analyse the major stock market index of each of the following eight countries: Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru, and Venezuela. For all the stock indices, the data is explored until December 31<sup>st</sup>, 2015 and starts in accordance with the data available in our database: Merval (Argentina) – October 19<sup>th</sup>, 1989; BOVESPA (Brazil) – January 3<sup>rd</sup>, 1994; IPSA (Chile) – September 27<sup>th</sup>, 1987; COLCAP (Colombia) – January 14<sup>th</sup>, 2008; IPC (Mexico) – January 4<sup>th</sup>, 1988; BVPSI (Panama) – January 1<sup>st</sup>, 1992; IGBVL (Peru) – January 2<sup>nd</sup>, 1991 and IBVC (Venezuela) – April 1<sup>st</sup>, 1993. More properly, in each index, we will focus on different barrier levels including the left and right side of the decimal point. Later on, a higher emphasis will be given to the psychological barriers more predominant for each one of them, in the cases, they do exist.

A doubt might arise from the reader: Why focus on stock indices if they are not traded? In fact, a stock index cannot be traded directly and it is only available for information purposes. However, it can be traded indirectly, for instance, through futures and options markets such as BM&FBovespa and Chicago Board Options Exchange (CBOE) where investors may adopt long or short positions on the different indices. In addition, since the introduction of Index Funds and Exchange-Traded Funds (ETFs) in 1976, with the Vanguard 500 Index Fund, and 1993, with the SPDR S&P 500 ETF, respectively, the indices gained even more relevance because both types of investment allow investors to replicate (passive investment) a variety of stock indices. Also, following a previous reference, the media attracts the attention of investors by giving breaking news on certain indices values reached. Finally, the investors may influence the tracker of the performance of the markets by trading their constituents.

We rely on the paper by Aggarwal and Lucey (2007) as our benchmark study. The authors tested the existence of psychological barriers in the gold prices using the same methodology as Donaldson and Kim (1993) in the Dow Jones Industrial Average (DJIA) and Dorfleitner and Klein (2009) in the analysis of four European stock indices and the prices of eight major stocks. Also, such hypothesised barriers have been explored in other locations, and asset classes: Burke (2001) examined United States Treasury benchmark bond yields; Koedijk and Stork (1994) observed the existence of psychological barriers in Europe, Asia and America stock indices; And, most recently, Dowling *et al.* (2016) discovered the presence of psychological barriers in oil futures market.

Hereby, our methodology process exhibits the following order: first, we perform a distribution uniformity test to evaluate whether or not they present the same likelihood of appearing. Second, a barrier proximity and barrier hump tests will be drawn to measure if the indices observations on or near a barrier occur significantly less frequently than a uniformity test would predict. In general, these tests examine the shape of the distribution for the various decimal digits combinations. Thirdly, conditional effects tests are also analysed on an attempt to identify the impact of psychological barriers on mean returns and variances of stock indices. In addition, difference tests will be executed to deeply understand the behaviour of the market before and after crossing a barrier both for returns and variances.

We found the consistency of psychological barriers in Argentina, Mexico, Panama and Peru. On the other hand, Brazil, Colombia and Venezuela show inconclusive results. In Chile, there is no evidence of barriers in every interval considered. When analysing the conditional effects, we detected that in a 10 day period, we still find clear evidence of market turbulence, especially before crossing a barrier from below, showing investors awareness of barriers in a period longer than 5 days.

Besides this chapter, the dissertation is structured as follows: in chapter 2, a literature review of the topic is made. In chapter 3, data and methodology are stated (including a summary table of data collection). In chapter 4, shows the estimation output and presents the analysis. In chapter 5, a rigorous conclusion is shown. And finally, it is mentioned the bibliographic references consulted.

## **2. Literature Review**

Behavioural Finance remains a field of Finance where there is no clear answer to numerous events. Since the early 90s, various journal articles have been published such as Donaldson (1990), De Grauwe and Decupere (1992) and Donaldson and Kim (1993) which were the firsts to explore the phenomenon of psychological barriers. They stated that some areas around round numbers were especially relevant for investors in the equity and foreign exchange markets despite no previous theory suggesting that these numbers should be particularly important in a totally rational market. Thenceforth, a set of several authors have investigated these “barriers” or “support levels” in different assets, time spans and even outside the financial markets as Lu and Giles (2010) showed. Consequently, as a broad and complex topic, it will call into question the market efficiency as the traditional Finance theory advocates. After the presentation of a brief definition for psychological barriers, we will focus our attention on the possible explanations for the behaviour and conclude the literature review by revising previous pertinent empirical studies.

### **2.1 Market Inefficiency**

The majority of academic theories foresees that the markets are efficient. Much of this thoughts is due to Fama (1970) where it was introduced the famous market efficiency theory. It stated that at any given point in time, prices of any asset, should “fully reflect” available information. In simple terms, it suggested that it is very unlikely to an investor have higher returns than the market (also known as abnormal returns) due to market efficiency. Nevertheless, from the growing interest in behavioural finance, we observe the publication of several studies where it is possible to notice the existence and persistence of anomalies which tend to repeat over and over again. Likewise, Simon (1955) had already expressed the idea that economic agents do not totally react in a rational way (expected in an efficient market) taking into consideration the impossibility of calculating the outcome of every possible solution. This result happens not only by the lack of information but also by the restrictions in obtaining it. As such, the author emphasized the relevant role of fully rational arbitrageurs.

Still, Shleifer and Vishny (1997) indicated the present of limits to arbitrage due to risks faced by these agents such as fundamental risk or implementation costs. These elements

make a motion to mispricing in the financial markets. Moreover, Hirshleifer (2001) exhibited that despite studies on market's inefficiencies like psychological biases, they remain persistent in financial markets, confirming the limitations regarding the role of arbitrageurs.

Furthermore, Bahng (2003) showed that the Taiwan example is a clear evidence of a violation of market efficiency because the random price levels should have the same distribution as a uniform distribution in efficient markets and they do not. Also, Sonnemans (2006) documented the cluster at round numbers. The author found that despite being not in a large number, are extremely robust, that is, contradicting the efficient market theory. Even Dorfleitner and Klein (2009) presented the existence of psychological barriers as being the proof of another anomaly that does not respect the efficient market hypothesis by stating the possibility of prediction in stock prices.

Finally, Feng and Seasholes (2005) tested whether sophistication and experience of professional investors helped to reduce or even eliminate behavioural biases like the disposition effect. The results show that even experienced investors are not immune to behavioural determinants.

## **2.2 Psychological Barriers and Other Related Effects/Events**

### **2.2.1 Psychological Barriers**

As mentioned by Jang *et al.* (2015, p. 54), "Psychological barriers, also called "barriers" or "support levels," are price levels that are perceived to be psychologically important to the extent that the market finds it difficult to reach these levels during upturns or downturns caused by the influx of selling or buying orders". The price frequency around those levels is weaker than in normal situations (where there are no barriers). On a daily basis during trading, these are barrier values where investors interpret it as being more important. According to Koedijk and Stork (1994), these levels appear to be based on no fundamental logic that justifies the behaviour around these regions but, for some reason, keep occurring and are maintained by mass psychology.

### **2.2.2 Bandwagon Effect**

The bandwagon effect, in practical terms, is described as an event where the rate of ideas or trends increases the most when it has been adopted by others. Initially referred by

Donaldson and Kim (1993) where they expressed the belief of investors in key reference points in the DJIA in which they tended to follow a bandwagon effect of entering a long/short position after a psychological important level was crossed whether it was from a upwards or downwards movement. In addition, Dorfleitner and Klein (2009) go even further by stating that this effect is a type of herding and it can be explained by the entrance of new market participants or the increase of demand by current investors due to previous positions adopted by other investors in the purchase of certain asset.

### **2.2.3 Clustering**

According to Mitchell (2001), individuals have a natural tendency to round numbers and, as a result, some numbers may appear more often than others. This trend is said to result from human bias and imprecise belief about the underlying asset. Psychological barriers differ from clustering by a different event, that is, lower frequency of trades around individual prices/levels. It is crucial to understand that clustering does not automatically involve that a barrier exists. However, an explanation for the existence of clustering may well be the same as a psychological barrier.

In addition, Dorfleitner and Klein (2009) referred one consequence of clustering which is called the “grouping effect” meaning that investors separate numbers into distinctive groups.

### **2.2.4 Media**

Shiller (1988) admitted that media may have a major influence on raising public awareness to regular patterns observed in social interactions. This can suggest that investors may not perceive the existence of psychological barriers immediately. Media has the capability of announcing behavioural/mental aspects alerting investors to some phenomena they had not paid enough attention at an earlier stage. However, from some moment in time, they may start looking at it with special interest.

## **2.3 Psychological Barriers' Reasons**

In this section, we will focus on explaining possible causes for the existence of psychological barriers. This part will be distributed as the following: anchoring and “roundophobia” (2.3.1), aspiration levels (2.3.2), odd pricing (2.3.3), cost efficiency (2.3.4) and price clustering (2.3.5).

### **2.3.1 Anchoring and Roundophobia**

Firstly mentioned by Tversky and Kahneman (1974) and then referred by Westerhoff (2003) and Aggarwal and Lucey (2007), anchoring is the phenomena where investors interpret a specific number to be particularly important. That happens because traders tend to use the nearest round number from the result they get by using fundamental analysis. The reason is to simplify the decisions by these economic agents. However, the estimate of any asset price, using this simple heuristic, provides an error of estimation.

Anchoring is closely related to “roundophobia”, “the fear of round number, where the round number gives a focus or an anchor for decision making rather than relating to underlying economic value” as clarified by Mitchell (2001, p. 401).

Westerhoff (2003) in the development of his behavioural exchange rate model showed excessive volatility because economic agents have a disposition to create their own trading signals. However, there is a tendency for investors to act within a restrict band around perceived fundamentals. Given that, the formations of resistance and support levels were observed which leads to the conclusion that there are psychological barriers in the foreign exchange market.

### **2.3.2 Aspiration Levels**

Simon (1955) built a model to explain investors' selling decisions. It was found that the assumed “economic man” by the traditional economic theory where that person is considered “rational” did not exist. In reality, there is an impossibility for investors to maximise their utility due to several factors namely information and time limitations. Thereby, in order to simplify the investment decision, they looked at the closest round number to their analysis and set it as a limit sell offer when they purchase the stock. This suggested the predefined idea of price investors think will be able to sell the stock in the future.

In particular, Sonnemans (2006) mentioned that even financial analysts typically use round numbers as target prices for individuals stocks. Again, this helps to establish a future sale price for a security recently bought. Example: an investor who buys a stock for 15 USD may expect the price of this stock to rise to 25 USD. This associated profit is considered to be an aspiration level. Furthermore, Cooney *et al.* (2003) found that on the

New York Stock Exchange (NYSE), there was data showing investors' tendency to submit limit orders is surprisingly higher with even-eighth prices than odd-eight prices.

Thus, it is inevitable that this phenomenon will generate psychological barriers because a huge number of limit orders at a specific round number will difficult the crossing of such levels, creating supports and/or resistances.

### **2.3.3 Odd Pricing**

This phenomenon is considered another explanation for the round number effect. Sonnemans (2006) defined it as the tendency to consider two very close numbers as they were entirely different. It is common to see in the marketing of consumer goods prices such as 9.95€ or 19.99€. Surprisingly, the closest round number (10€ and 20€, respectively) is considered to be distant from the previously mentioned non-round numbers as stated by Friedman (1967), Holdershaw *et al.* (1997), Stiving and Winer (1997) and Schindler and Kirby (1997). Palmon *et al.* (2004) concluded the same but in real estate prices. The authors showed that transaction prices usually display two different price-endings: even (000-ending) and just-below-even (900-ending). Similarly, Folkertsma (2002) discovered that 31% of observed prices of all consumer goods in the Dutch consumer price index ended in 9 and 20% of the price end in 98 or 95 cents. Besides, Kashyap (1995) emphasized the fact that consumers, in general, tend to consider the odd price as significantly lower than the round numbered price.

Furthermore, Brenner and Brenner (1982) highlighted the importance of numbers on the left side of the decimal point that is where consumers pay more attention. When a price was quoted at 99.95€, for instance, consumers had the tendency to focus only on the 99 figure. The authors justified it by the limits of human memory. As a consequence, consumers look at what it is easier to remind.

The same occurs in the financial markets. Without any fundamental explanation, an investor who finds a stock at 19.90€ perceives it as significantly lower than 20€. Thus, a current stock owner is much more willing to sell at 20€ than 19.90€ despite the minimal difference. The same applies to a potential buyer who is reluctant to purchase a stock that is already over 20€.



### **2.3.4 Cost Efficiency**

Following the similarity to odd pricing, Preece (1981) presented the haziness on individual thoughts when confronted with numbers. They are highly likely to mentally simplify new information focusing on the round numbers. As a result, this enables them to produce a faster and more cost-effective judgment. Actually, Hornik *et al.* (1994) seemed to confirm the broader use of round numbers as opposed to what would happen in a random process. In particular, they found this tendency to be stronger in higher values.

In addition, Mitchell (2001) and Sonnemans (2006) affirmed the convenience of using round numbers (which appears to be a human habit) since it makes the calculations much easier. Sonnemans (2006) also stated that the decision of using round numbers, not only limits informational load but also reduces the probability of costly mistakes. Nowadays, taking into account the confirmation screen on any online platform, there is a very small risk of errors in the financial transactions.

### **2.3.5 Price Clustering**

Initially mentioned by Osborne (1962) and Niederhoffer (1965a, 1965b) regarding clustering on whole numbers in the U.S. stock market, it was later developed by Mitchell (2001). The author separated two concepts next to each other: clustering (referred in Section 2.2.3) and price clustering. The second term was defined as “a concentration of the distribution associated with a particular value or values when various values of price (digits) occur more frequently than other prices (digits)”. As such, psychological barriers differentiate from clustering and price clustering by the difficulty in overtake certain values of prices.

## **2.4 Empirical Studies**

Earlier empirical studies regarding psychological barriers have been profoundly studied throughout several years and are mainly divided by geographical areas, time horizons and asset classes. The majority is focused on the equity market especially in the U.S. However since the early 2000s this phenomenon has been expanded to a group of assets such as bonds, foreign exchange, futures, options and commodities.

#### **2.4.1 Stock Indices and Individual Stocks**

Donaldson and Kim (1993) were the firsts to clearly understand the possible impact of psychological barriers in one of the main stock index of the U.S., the Dow Jones Industrial Average (DJIA). The authors wished to know what happens to the index when it reaches levels which are more appealing to investor's sight by its simplicity but have no fundamental justifications to occur. The study discovered the existence of barriers, both supports and resistances, at 100-levels in the index (e.g., 1800, 1900, 2000, etc.). Even several financial newspapers make a point in highlighting this phenomenon when some levels are about to get touched (explored in Section 2.2.4). The results showed that trades happen less frequently in index values near 100-levels demonstrating the existence of barriers. The authors finalised their conclusion by leaving an open question on whether the markets are fully rational and the values observed are, in fact, of genuine value. Or, conversely, the economic agents are not rational and use certain levels as "sentiment signals on which to base their buying/selling decisions", Donaldson and Kim (1993, p. 329). Likewise, psychological barriers in the DJIA were widely studied by Ley and Varian (1994). Instead of focusing their attention from 1974 to 1990 like the previous mention authors, they opted by expanding for almost half a century their research (1952-1993). It also confirmed the fewer observations around 100-levels. Both empirical studies concluded the impossibility of predicting future movements in the stock index due to these barriers. More recently, Woodhouse *et al.* (2016) found the same 100-levels for the NASDAQ Composite concluding as well the presence of psychological barriers.

A broader study was conducted by Koedijk and Stork (1994) following the concept of psychological barriers as introduced by Donaldson (1990). These authors observed indices of Belgium, Germany, Japan, U.S. and United Kingdom to achieve the same results as the authors above. Additionally, it is added the importance of reflection concerning this existence as not being just a sample bias. Moreover, the authors reinforced the unpredictability of stock returns.

Cyree *et al.* (1999) after analysing eight major stock indices showed that there is no consistency about mean effects and variance effects. However, it was possible to state some general conclusions such as "Upward movements through barriers tend to have a consistently positive impact on the conditional mean return, while downward movements

tend to have an indeterminate impact” and “conditional variance tends to be higher in pre-crossing subperiods and lower in post-crossing subperiods”, Cyree *et al.* (1999, p. 87).

In the early 2000s, Bahng (2003) studied the existence of psychological barriers in seven Asian stock markets between 1990 and 1999 indicating its presence in the Taiwan Weighted Stock Index. The author followed the same methodology as Donaldson and Kim (1993) to discover that price index levels were not uniformly distributed as expected by the efficient market hypothesis which states a random distribution of price levels. Contrary to Cyree *et al.* (1999), no conditional effects on returns and variances were explored, which might reduce the significance of the results.

What is more, Dorfleitner and Klein (2009) focused their study in examining four European stock indices and eight major German stocks. The data sample ranged principally from May 02, 1996 to June 30, 2003. As a more recent journal article, the authors showed that psychological barriers' effect seems to have disappeared due to previous studies on this subject. However, the fragile traces of psychological barriers were less weak for indices than for stocks which may be surprising due to the direct influence of traders in share's value.

#### **2.4.2 Bonds**

Burke (2001) primary purpose was to research the “United States Treasury benchmark 10-year and 30-year bond yield series for empirical evidence of barriers” from January 4, 1983, to January 10, 2000. Looking for multiples of 0.25%, the author observed the lower frequency of yield values near points such as 6.00%, 6.25%, 6.50%, 6.75% suggesting the existence of barriers on those values. Monte Carlo simulations confirmed the robustness of these findings.

#### **2.4.3 Foreign Exchange**

De Grauwe and Decupere (1992) studied for the first time the existence of psychological barriers in the foreign exchange market namely in the USD/DM<sup>1</sup> and the USD/JPY exchange markets. The authors used the same methodology as Donaldson (1990) to analyse daily quotations of both pair of currencies from 1980 to 1990. It was found a

---

<sup>1</sup> DM means Deutsche Mark, former official currency of West Germany (1948-1990) and unified Germany (1990-2002).

weak evidence of psychological barriers in the USD/DM market. It was even used the inverted quotation to observe no definite conclusions. However, the empirical results suggested that it was not the case for the USD/JPY market. Considering the number of JPYs per one USD, figures such as 130 and 140 have an impact on investors' decisions, that is, the market seems to resist movements toward these numbers.

Focusing on the EUR/USD exchange rate, Westerhoff (2003, p. 65) used a behavioural exchange rate model assuming traders prefer to extend "the nearest round number as a proxy for the fundamental value". As a result, this lead to a continuous misaligned of the foreign exchange market. Nonetheless, the author concluded by confirming the importance of central authorities in reducing or even eliminate distortions despite the difficulty in breaking psychological barriers between anchors.

Finally, Mitchell and Izan (2006) investigated the same phenomena in the Australian dollar. Contrary to previous studies, the authors used a simulation analysis rather than a uniform test to reveal the still existence of psychological barriers, however, much less pronounced and no longer significant.

#### **2.4.4 Futures and Options**

Concerning futures, Schwartz *et al.* (2004) analysed daily trade data from Chicago Mercantile Exchange for S&P 500 futures contracts only for two years (1999 and 2000). The results showed evidence of clustering at pricing increments of x.00 and x.50. Furthermore, it was found a positive correlation between price clustering and volatility whereas a negative correlation was discovered amid price clustering and volume. The point is the fact that if there was a cluster around these increments, there would be more confidence to halt the presence of psychological barriers.

Moreover, Chen and Tai (2011) were the firsts to examine TAIFEX futures market. The investigation advocated strict barriers around hundred points but not in thousand points. Round numbers act as important barriers that have an impact in the conditional mean and variance of the futures price series over psychological barriers. Notwithstanding, not all psychological barriers exhibit effects due to round futures price series.

In a very recent study, Dowling *et al.* (2016) searched for the presence of psychological barriers around 10\$ price levels in the WTI<sup>2</sup> and Brent<sup>3</sup> futures. This existence was seen in the Brent futures but not in the WTI futures due to the higher relevance in the global market and the complexity around fundamental value in Brent futures. Before the crisis of 2008, namely from 1990 to 2006, psychological barriers had a significant impact in the 10\$ barrier regions. However, after 2008, the markets appeared not to focus on technical behaviours anymore, but instead, looking to fundamentals explications.

On the field of options, Jang *et al.* (2015) focused on analysing the 15-minute interval of the S&P 500 and VIX<sup>4</sup> indices from July 8, 2011, to January 19, 2012. Three tests (the Kolmogorov-Smirnov, barrier proximity and barrier humps tests) were used to confirm the assumption of psychological barriers in 100 levels of the S&P 500 index. The authors realised that VIX index tended to decline relatively by 0.5% on average when the S&P 500 index was close to a barrier. Why? Because it did not follow a simple mean-reverting process but was dependent on the barriers.

#### **2.4.5 Commodities**

The subject of psychological barriers has also been examined on commodities. Aggarwal and Lucey (2007) studied daily gold prices for the period of 1980-2000 and intraday gold prices between 2001 and 2003. Thus, the authors started by firstly performing a uniformity tests to notice how frequent the 10's and 1's digits appear in the data. However, the results of these tests were not sufficient to conclude the existence of barriers even if a rejection of uniformity occurred. Secondly, barriers tests (namely barrier proximity test and barrier hump test) were conducted to detect if observations appeared less frequently than a uniform test would expect in the surroundings of barriers. And thirdly, conditional effects were followed to discover if "the dynamics of the return series" differed from the other values. All in all, this paper noted the importance of round numbers as elements that "act as barriers with important effects on the conditional mean

---

<sup>2</sup> WTI, West Texas Intermediate, is a light crude oil used as a benchmark in oil pricing.

<sup>3</sup> Brent is a light and sweet crude oil, though not as light or sweet as WTI.

<sup>4</sup> Jang *et al.* (2015, p. 54): "The VIX Index is a measure of the market's expectations of stock market volatility over the next 30-day period and is a popular measure of the implied volatility of S&P 500 Index options."

and variance of the global price series around psychological barriers”, Aggarwal and Lucey (2007, p. 217).

In recent times, Lucey and O'Connor (2016) studied intra-day data from 1975 to 2015 both for gold and silver. In terms of gold, this paper is an extent of Aggarwal and Lucey (2007). The conclusions remained the same as before, that is, gold prices occurs less frequently in values ending in 0 and 00.

Relatively to silver, the authors found no significant evidence of barriers at neither 0 nor 00 ending digits.

### 3. Data and Methodology

In this chapter, we will present the methodological aspects such as data and the explanation regarding the tests performed. Our methodology will be mainly based on Aggarwal and Lucey (2007) but complemented by papers from different asset classes.

#### 3.1 Data

The components of our research are the major stock indices of the Latin America's countries analysed. This study investigates the behaviour of the major stock indices of eight Latin America countries: Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru and Venezuela. This option is justified by its relevance, available data and market size. The daily data for this study is drawn from DataStream and the website *Bolsa de Valores de Colombia*<sup>5</sup>. The starting dates vary according to data availability until December 31<sup>st</sup>, 2015.

The following table is a summary of the data examined:

**Table 1** – Data Explored in the Study

Countries	Stock Index	Starting date	Ending date	Database
Argentina	MERVAL	October 19 <sup>th</sup> , 1989	December 31 <sup>st</sup> , 2015	DataStream - Thompson Reuters; <i>Bolsa de Valores de Colombia</i>
Brazil	BOVESPA	January 3 <sup>rd</sup> , 1994		
Chile	IPSA	September 27 <sup>th</sup> , 1987		
Colombia	COLCAP	January 14 <sup>th</sup> , 2008		
Mexico	IPC	January 4 <sup>th</sup> , 1988		
Panama	BVPSI	January 1 <sup>st</sup> , 1992		
Peru	IGBVL	January 2 <sup>nd</sup> , 1991		
Venezuela	IBVC	April 1 <sup>st</sup> , 1993		

As shown in Table 1, the period of analysis is not the same for all countries. For instance, COLCAP is the index with the shortest number of years considered (8 years) and both IPSA and IPC present the highest number of years in study (28 years).

---

<sup>5</sup> <https://www.bvc.com.co/pps/tibco/portalbvc>

Description of each stock index following the same order as Table 1<sup>6</sup>:

**MERVAL:** Major stock market index in Argentina which tracks the performance of companies with high market capitalisation. It is a weighted basket index and revised every 3 months, taking into account the trading volumes over the past 6 months.

**BOVESPA:** The leading stock market index in Brazil, tracking around 50 most liquid stocks traded on the Sao Paulo Stock Exchange. It is a gross total return weighted index.

**IPSA:** Major Chile's index is a total return index and is composed of the 40 stocks with the highest average annual trading volume in the Santiago Stock Exchange.

**COLCAP:** Market capitalisation weighted major index in Colombia which includes the 25 most liquid stocks listed in the Colombia Stock Exchange.

**IPC:** The leading Mexican's stock index is a capitalisation weighted index of the top stocks traded on the Mexican Stock Exchange.

**BVPSI:** The starring Panama's stock index which tracks the performance of the biggest companies listed on the Panama Stock Exchange.

**IGBVL:** The primary Peru's stock index which tracks the performance of the largest and most actively traded stocks listed on the Lima Exchange. It is a value-weighted index.

**IBVC:** The most relevant stock market index, tracking the most liquid stocks traded on the Caracas Stock Exchange (Venezuela). It is a capitalization-weighted index.

From now on, we will use the name of the country to mention its major index in order to make it easier for the reader to analyse our results. We believe that this approach is more intuitive.

---

<sup>6</sup> Sources: DataStream, Bloomberg and Trading Economics.



### 3.2 Methodology

Since the publication regarding psychological barriers in the Dow Jones Industrial Average by Donaldson and Kim (1993), the methods used to find the existence and impact of psychological barriers have not suffered any major changes<sup>7</sup>.

Following the previous authors, we will perform a uniformity test to examine the frequency of the distribution of the *M*-values (1's, 10's, 100's, 1000's and 10000's digits – explained in detail in Section 3.2.1). As shown by Ley and Varian (1994), the conclusion of non-uniformity distribution does not necessarily imply the existence of psychological barriers. Then, using the in-depth approach by Donaldson and Kim (1993) and Burke (2001), barrier tests will be performed to observe if the distributions occur less frequently than a uniform distribution would predict around the barriers. This includes barrier hump test which examines the shape of the frequency distribution and barrier proximity test which focused on the frequency of observations in close proximity to the barriers. Finally, the conditional effects tests demonstrate the differences that may exist between crossing a barrier from an upward and a downward movement regarding return and variance as described by Cyree *et al.* (1999).

A summary of our data series can be seen in the following table:

**Table 2** – Summary Statistics on Latin America's Indices Data Series

Country	N	Return series					Level series	
		Mean	SD	Skewness	Kurtosis	Jarque-Bera (p-value)	Min	Max
Argentina	6835	0.000930	0.027991	-2.138783	90.23957	0.000000	15.89	14173.87
Brazil	5738	0.000825	0.022271	0.513736	14.89715	0.000000	380.09	73516.00
Chile	5809	0.000334	0.011119	0.237394	10.76731	0.000000	538.01	5040.97
Colombia	2079	0.000058	0.011059	-0.633427	9.714583	0.000000	686.64	1942.37
Mexico	7303	0.000828	0.015262	0.068445	10.42913	0.000000	86.61	46357.24
Panama	6261	0.000540	0.008115	5.102059	163.41840	0.000000	13.70	478.75
Peru	6521	0.000914	0.014736	-0.076298	11.31932	0.000000	22.92	24051.62
Venezuela	5935	0.001651	0.017485	0.836699	21.70214	0.000000	0.76	15580.47

<sup>7</sup> Except to the introduction of Benford's Law by De Ceuster *et al.* (1998) which has been used by Lu and Giles (2010) and Shawn and Kalaichelvan (2012). In our study, we will focus only on the major methodologies applied so far.

From Table 2, we take notice of several aspects: First, the values contradict the normal distribution (Jarque-Bera test). Secondly, the average returns are positive for all series. Thirdly, Argentina and Brazil present the most volatile markets in the region. Fourthly, all the stock markets show a higher number of outliers that a normal distribution would predict. Last but not least, there is no pattern in the asymmetry of the distributions (some are asymmetric on the left and others on the right).

As referred before, Aggarwal and Lucey (2007) will be our main reference paper and, as a result, the majority of our tests come from that paper<sup>8</sup>. The tests performed appear to use the most reliable methodologies, so far, for the study of psychological barriers. Moreover, taking into account the particularities of our data, additional approaches will be applied (example: the study of 10000's digits).

### **3.2.1 Definition of Barriers**

Following the work of Dorfleitner and Klein (2009) in some European stock markets, we will introduce the barrier level  $l$  as the number of zeroes that a barrier has. For this purpose, we will apply a "band technique" as mentioned by Brock *et al.* (1992). This technique allows us to define a barrier as an interval between two numbers at the same distance to an actual barrier number<sup>9</sup>. This interpretation supports the idea that market players will show more activity on index levels such as 980 points or 1020 points rather than 1000 points, for example. We define the multiples of 1, 10, 100, 1000 and 10000 and the intervals with an absolute length of 2%, 5%, 10% and 25% to the corresponding barriers. Thus, these are the restriction bands considered:

- Barrier level  $l = 4$  (10000s): 9800-200; 9500-500; 9000-1000; 7500-2500
- Barrier level  $l = 3$  (1000s): 980-20; 950-50; 900-100; 750-250
- Barrier level  $l = 2$  (100s): 98-02; 95-05; 90-10; 75-25
- Barrier level  $l = 1$  (10s): 9.8-0.2; 9.5-0.5; 9.0-1.0; 7.5-2.5
- Barrier level  $l = 0$  (1s): 0.98-0.02; 0.95-0.05; 0.90-0.10; 0.75-0.25

---

<sup>8</sup> The methodologies used by Aggarwal and Lucey (2007) are cited from other papers meaning that respective authors will be mentioned in accordance to specific tests.

<sup>9</sup> Usually presented as a strict barrier where an index value ends at "00".

We will not choose to perform all the barriers levels at all the indices. In our opinion, it only makes sense to examine some barriers according to the values of each index. For instance, Panama does not reach levels over 1000 points which means that only until the barrier level  $l=2$  will be examined.

### **3.2.2 $M$ -values**

When analysing the existence of barriers, it is typical to restrict its investigation to the numbers around and preceding the decimal point.  $M$ -values translate into the frequency that certain price levels (in our case, points) relatively close to a barrier occur compared to others. If we consider a 100 level ( $M100$ ), we analyse how often an index closes at 500, 600, 700, ..., that is, at  $M = 00$  and determine if these levels occur less frequently than others in the middle range (example: 640, 750, 820,...) as affirmed by Donaldson and Kim (1993). If this is so, we may be in presence of psychological barriers.

As stated before, our  $M$ -values divisions will be in accordance with the data obtained for each stock index. Two examples may be shown: in Venezuela stock index, the study of  $M0.1$  (the two values to the right of the decimal point) will be particularly relevant, however, in Colombia's case the pertinence is higher at  $M100$ .

The different values corresponding to our data are distinct from each other and, as a result, it is crucial to decide where a psychological barrier might occur (in case they do exist). The most common approach is to consider values around 100, 200,... and 2600, 2700,... as potential barriers as explained by Donaldson (1990), Donaldson and Kim (1993) and Ley and Varian (1994):

$$k \times 100, \quad k = 1, 2, \dots \quad (3.1)$$

Nonetheless, De Ceuster *et al.* (1998) revealed the existence of two problems. Firstly, the non-regenerative factor, i.e., a value of 2600 may be considered a barrier, but not a value of 260. This leads the authors to question the relevance of the position of the decimal point. Secondly, the increase in the values of the stock indices tends to reduce to zero the gap between barriers. Thus, following Eq. (3.1), as indices become larger, the less intuitive their levels are to be representative of a psychological barrier. Then, we should

consider the possibility of barriers at the levels..., 10, 20, ..., 100, 200, ..., 1000, 2000, 10000, 20000, ..., i.e. at:

$$k \times 10^l, k = 1, 2, \dots, 9; l = \dots, -1, 0, 1, \dots; \quad (3.2)$$

And, in another way, at the levels ..., 10, 11, ..., 100, 110, ..., 1000, 1100, ..., 10000, 11000, ..., i.e. at:

$$k \times 10^l, k = 10, 11, \dots, 99; l = \dots, -1, 0, 1, \dots; \quad (3.3)$$

Following these barriers,  $M$ -values can now be defined. For barriers at levels defined by Eq. (3.1), these are the pair of digits preceding the decimal point.

$$M_t^a = [P_t] \bmod 100, \quad (3.4)$$

where  $[P_t]$  is the integer part of  $P_t$  and  $\bmod 100$  denotes reduction modulo 100. For barriers at the levels defined by Eqs. (3.2) and (3.3), the  $M$ -values would be determined, respectively, by the second and third significant digits and third and fourth significant digits. Formally,

$$M_t^b = [100 \times 10^{\log P_t \bmod 1}] \bmod 100, \quad (3.5)$$

$$M_t^c = [1000 \times 10^{\log P_t \bmod 1}] \bmod 100, \quad (3.6)$$

where logarithms are to base 10. It means in practice that if  $P_t = 2544.36$ , then  $M_t^a = 44$ ,  $M_t^b = 54$  and  $M_t^c = 44$ . Additionally, all  $M$ -values are in the set  $\{00, 01, \dots, 99\}$  with the value 00 representing a possible psychological barriers. Following the psychological barriers principle, it is natural for the market not to close near a 00 number as affirmed by De Grauwe and Decupere (1992).

### **3.2.3 Uniformity Test**

After clearly defining all the  $M$ -values, a uniformity test is followed regarding the distribution of the frequency of appearance of the several digits involved. In order to test it, we will opt by the Aggarwal and Lucey (2007) method using the Kolmogorov-Smirnov

approach which tests the null hypothesis that the population distribution from which the data sample is drawn is a uniform distribution.

In case the null hypothesis is rejected, we will conclude the non-uniformity of the distribution, however, these findings will be limited because, as shown by Ley and Varian (1994) in the Dow Jones Index, a rejection of uniformity is not in itself sufficient to show the existence of barriers. Additionally, De Ceuster *et al.* (1998) alerted that the higher the series, the intervals between barriers widens and consequently, the theoretical distribution of digits and frequencies of occurrence is no longer uniform.

### **3.2.4 Barrier Tests**

Firstly mentioned by Donaldson and Kim (1993), later explored by Burke (2001) in the U.S. Bond Yields and by Aggarwal and Lucey (2007) in gold prices, the barrier tests are drawn to measure whether or not the indices observations on or near a barrier occur significantly less frequently than a uniformity test would predict. In general, these tests examine the shape of the distribution for the various decimal digits combinations. The tests mentioned are the following:

#### **a) Barrier proximity test**

This test studies the frequency of  $M$ -values in close proximity to psychological barriers. We will be using the same approach:

$$f(M) = \alpha + \beta D + \varepsilon \quad (3.7)$$

where  $f(M)$  is defined as the frequency that an index closes with its last two digits, minus 1 percentage point and  $D$  is the dummy variable where the dummies are defined as:

- $D_{98-02} = 1$  if  $M \geq 98$  or  $M \leq 02$ ,  $= 0$  otherwise
- $D_{95-05} = 1$  if  $M \geq 95$  or  $M \leq 05$ ,  $= 0$  otherwise
- $D_{90-10} = 1$  if  $M \geq 90$  or  $M \leq 10$ ,  $= 0$  otherwise
- $D_{75-25} = 1$  if  $M \geq 75$  or  $M \leq 25$ ,  $= 0$  otherwise

These are the levels referred in Section 3.2.1 and, as a result, we will not only consider an exact number but also intervals as a psychological barrier. The presence of barriers will result in a lower frequency of  $M$ -values at the barrier and, as a result, there is a statistically significant negative relationship between  $f(M)$  and  $D$ .

b) Barrier hump test

This test is particularly focused on the entire shape of the distribution rather than only on the  $M$ -values frequency distribution immediately around the barriers. Here, as Donaldson and Kim (1993) stated, the distribution should not only be uniform in the absence of barriers as a specification of the null hypothesis but also have a particular shape if they do exist. Besides, the work of Bertola and Caballero (1992) exhibited that this test is an adequate method for the distribution of observations.

Using the same approach, the barrier hump test is implemented by the following equation:

$$f(M) = \alpha + \phi M + \gamma M^2 + \eta \quad (3.8)$$

where  $f(M)$  represents the frequency with which an index closes with its last two digits, minus 1 percentage point. Under the null hypothesis of no barriers,  $\gamma$  should be zero, whereas under the existence of barriers, there is a statistically significant negative relationship between  $f(M)$  and  $M^2$ .

### **3.2.5 Conditional Effects tests**

Following Cyree *et al.* (1999), the performance of conditional effects tests is made to detect changes in the conditional mean and variance of the returns distribution during the sub-periods before and after crossing a barrier. These authors use a 10 days window before and after the barrier crossing as previously illustrated by Brock *et al.* (1992) but Aggarwal and Lucey (2007) devote a 5 days analyses before and after crossing a barrier. As a result, we will study both approaches.

To deeply examine the conditional effects, a GARCH (1,1) model will be implemented as considered to be an appropriate model to explore the index return dynamics. Aggarwal and Lucey (2007)<sup>10</sup> also used the same model to scrutinise the differential effects on returns whether the barriers were being approached on an upward or downward movement.

---

<sup>10</sup> Likelihood ratio test was performed.

Thus, the four regimes around barriers will be defined as:

BD: dummy variable which assumes the value 1 in the 5 or 10 days before the prices reach a barrier on a downwards movement and the value 0 otherwise;

AD: dummy variable which assumes the value 1 in the 5 or 10 days after the prices reach a barrier on a downwards movement and the value 0 otherwise;

BU: dummy variable which assumes the value 1 in the 5 or 10 days before the prices reach a barrier on an upwards movement and the value 0 otherwise;

AU: dummy variable which assumes the value 1 in the 5 or 10 days after the prices reach a barrier on an upwards movement and the value 0 otherwise;

Moreover, a complete analysis of the effect of barriers requires the analysis of the mean and variance equations – eqs. 3.9 and 3.11, respectively:

$$R_t = \beta_1 + \beta_2 BD_t + \beta_3 AD_t + \beta_4 BU_t + \beta_5 AU_t + \varepsilon_t \quad (3.9)$$

$$\varepsilon_t \sim N(0, V_t) \quad (3.10)$$

$$V_t = \alpha_1 + \alpha_2 BD_t + \alpha_3 AD_t + \alpha_4 BU_t + \alpha_5 AU_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t \quad (3.11)$$

In the absence of barriers, the coefficients on the indicator variables in the mean equation would be equal to zero.

Following Cyree *et al.* (1999) and, more recently, Aggarwal and Lucey (2007), the four possible hypotheses to be tested are:

H1: There is no significant difference in the conditional mean return before and after a downwards crossing of a barrier;

H2: There is no significant difference in the difference in conditional mean return before and after an upwards crossing of a barrier;

H3: There is no significant difference in the difference in conditional variance before and after a downwards crossing of a barrier;

H4: There is no significant difference in the difference in conditional variance before and after an upwards crossing of a barrier.

## **4. Empirical Study**

In this section, the results regarding uniformity, barrier tests and conditional effects will be disclosed. As there is an absence of prior research in our geographical area, we have no priori expectation concerning the results achieved. Then, an analysis will be made of each one of them.

### **4.1 Uniformity Test**

Table 3 shows the results of the uniformity tests performed for the different  $M$ -values (M0.1, M1, M10, M100 and M1000) derived from the data. At 10% significance level, we do not reject the null hypothesis at M0.1 in Brazil, Colombia and Mexico; at M1 in Chile and Colombia and at M10 only in Mexico. Considering a 5% significance level, the number of not rejecting the null hypothesis increases by one, Argentina, at M0.1. At M10, Brazil and Venezuela are added. Finally, looking to 1% significance level, we do not reject additional cases such as Chile at M0.1, Argentina at M1 and Colombia at M10. Moreover, Panama is the only country with statistical significant results for all levels. Also, the uniformity test seems to show that the higher the  $M$ -values, the more statistical significance are the results. Uniformity is clearly rejected by the vast majority of indices under consideration. Therefore, there is strong evidence overall that the  $M$ -values are not uniformly distributed in the indices of the countries studied. However, as indicated in Section 3.2.3, the process of rejecting uniformity is not in itself sufficient to show the existence of barriers.

Moreover, it is crucial to point out that, according to the particularities of our data<sup>11</sup>, the analysis of uniformity regarding some  $M$ -values did not include the total observations indicated in Table 2. In Argentina, out of the total 6835 observations only 2941 were considered to study the M100 and only 214 were used to study the M1000. In Mexico, out of the total 7303 observations, only 3075 were deemed to analyse the M1000. Lastly, in Venezuela, out of the total 5935 observations, only 1096 are exploited for the M10, 649 for the M100 and 158 for the M1000.

---

<sup>11</sup> Example: Indices with a value lower than 1000 points cannot be studied in levels at M100 and M1000.



**Table 3** – Kolmogorov-Smirnov test for uniformity

Country	M0.1 ( $l=0$ )	M1 ( $l=1$ )	M10 ( $l=2$ )	M100 ( $l=3$ )	M1000 ( $l=4$ )
Argentina	1.2843 (0.0738)*	1.5080 (0.0212)**	2.5877 (0.0000)***	8.5761 (0.0000)***	9.8682 (0.0000)***
Brazil	1.1264 (0.1581)	5.0241 (0.0000)***	1.3029 (0.0671)*	7.4010 (0.0000)***	75.6622 (0.0000)***
Chile	1.5140 (0.0204)**	1.1853 (0.1204)	2.1372 (0.0002)***	17.3372 (0.0000)***	-
Colombia	0.8746 (0.4288)	1.1847 (0.1207)	1.4204 (0.0354)**	8.2443 (0.0000)***	-
Mexico	1.1184 (0.1638)	2.1404 (0.0002)***	1.1626 (0.1339)	8.1189 (0.0000)***	10.1611 (0.0000)***
Panama	2.8199 (0.0000)***	6.4622 (0.0000)***	17.9263 (0.0000)***	-	-
Peru	1.9372 (0.0011)***	2.1206 (0.0002)***	2.4100 (0.0000)***	10.3814 (0.0000)***	-
Venezuela	1.7060 (0.0059)***	6.9328 (0.0000)***	1.2623 (0.0826)*	1.9841 (0.0008)***	6.2357 (0.0000)***

This table presents the results of a Kolmogorov-Smirnov test for uniformity. The first line in each country shows the value of the t-statistic, while  $p$ -value gives the marginal significance of this statistic. H0: uniformity, H1: non-uniformity. The null hypothesis is rejected in the majority of cases with exception to six cases at 10% significance level, it is not rejected for nine cases at 5% significance level, and it is not rejected for twelve cases at 1% significance level. Note:  $p$ -values are in parentheses. Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

## 4.2 Barrier Tests

### 4.2.1 Barrier Proximity Test

From Table 4 to Table 8, we show the results for all the intervals of barriers mentioned in Sections 3.2.1 and 3.2.4. Following the methodology explained in Section 3.2.4, we expect a statistically significant negative relationship between  $f(M)$  and  $D$ , suggesting a lower frequency of  $M$ -values at these points.

Starting by looking at the strict barrier level (00) in Table 4, we find that only Brazil presents a barrier at the M1000 level for a 10% significance level. In other cases, we observe negative estimates for parameter  $\beta$ , however, the  $p$ -values are all over 10% which it does not support what states the theory regarding the frequency of  $M$ -values at barrier points.

For the interval 98-02 in Table 5, we only observe negative estimates and significant relationship between  $f(M)$  and  $D$  in Panama for M0.1 level and Mexico, Peru and Panama for M100 at the 5% significance level. Curiously, Mexico seems perfectly uniform at M1000 level.

As we keep widening the barrier intervals, the existence of barriers at different levels has the tendency to appear more significant. At the 95-05 barrier in Table 6, Peru and Mexico exhibit barriers for M100 at the 1% significance level. Argentina and Panama present a statistically significant result at M100 and M0.1, respectively, for a 5% significance level. Colombia shows a 10% significance level at M100. Finally, Panama also seems to indicate a significant level at 5% for M100 level. Like Mexico in Table 5, Chile appears to show perfectly uniformity for M100 as well.

Considering the 90-10 interval stated in Table 7, Panama shows the most powerful results for the M0.1 level whereas Colombia and Mexico indicate significant outcomes for the M100 level, both at the 1% significance level. Moreover, Peru appears to be the first and only country where we observe the existence of barriers for M10 at the 5% significance level. Moreover, the number of thoroughly uniformity has just increased from the previous shorter interval. Not only, Chile and Mexico present the same phenomena but also Peru for M100.

Lastly, in the 75-25 interval in Table 8, we can reject the no barrier hypothesis for Argentina and Panama for M0.1 and M10, respectively, at the 5% significance level, Mexico for M100 at the 1% significance level and Colombia at the 10% significant level.

Notably, both Venezuela and Peru for M100 level do not present the existence of barriers at a wider interval such as 90-10 and 75-25 despite its existence at 98-02 and 95-05 intervals suggesting the possibility that investors only react near the round number in those stock indices.

**Table 4** – Barrier Proximity Test: Strict Barrier (00)

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>
Argentina	-0.0609	0.3382	0.0018	-0.0104	0.4699	0.0001	0.2323	0.9602	0.0310	-0.0254	0.1050	0.0017	-0.0699	0.3665	0.0006
Brazil	0.2826	0.7415	0.0043	5.6762	0.9992	0.0968	0.0510	0.6323	0.0012	-0.0048	0.3697	0.0001	-0.0063	0.0861*	0.0005
Chile	0.1520	0.8702	0.0129	0.1722	0.8973	0.0163	0.1519	0.8637	0.0123	0.0147	0.7545	0.0005	-	-	-
Colombia	0.2327	0.8742	0.0134	0.2324	0.8432	0.0103	0.2327	0.8480	0.0108	0.0366	0.8002	0.0013	-	-	-
Mexico	0.1013	0.8172	0.0084	0.0404	0.6122	0.0008	0.0400	0.6177	0.0009	0.0104	0.6047	0.0001	-0.0081	0.3921	0.0001
Panama	-0.0300	0.4670	0.0001	-0.3026	0.3393	0.0018	-0.0402	0.4808	0.0000	-	-	-	-	-	-
Peru	1.3136	0.9960	0.1097	0.1712	0.8782	0.0138	-0.1617	0.1794	0.0086	-0.0071	0.4608	0.0000	-	-	-
Venezuela	-0.0601	0.3929	0.0008	-0.2124	0.3418	0.0017	0.2723	0.7497	0.0046	-0.0217	0.3888	0.0002	0.5964	0.9998	0.1970

This table shows the results of the regression  $f(M) = \alpha + \beta D + \varepsilon$  where the dependent variable is the frequency of appearance of  $M$ -values and  $D$  is a dummy variable that takes the value 1 in the presence of a strict barrier ( $M=00$ ) and 0 otherwise. Test H0 (no barriers):  $\beta = 0$  vs. H1 (barriers are present):  $\beta < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

**Table 5** – Barrier Proximity Test: 98-02 Barrier

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>
Argentina	- 0.0256	0.3506	0.0015	0.0671	0.8581	0.0117	0.0737	0.8874	0.0150	- 0.0156	0.1336	0.0013	- 0.0038	0.4680	0.0000
Brazil	- 0.0447	0.3689	0.0011	- 0.1077	0.4245	0.0004	0.0337	0.7674	0.0055	- 0.0003	0.4831	0.0000	0.0008	0.8186	0.0002
Chile	0.0511	0.7961	0.0070	0.0089	0.5571	0.0002	0.1099	0.9451	0.0308	0.1454	0.9899	0.1004	-	-	-
Colombia	0.0825	0.8131	0.0081	0.1369	0.9037	0.0173	- 0.0038	0.4854	0.0000	0.0401	0.9559	0.0053	-	-	-
Mexico	0.0298	0.7197	0.0035	- 0.0126	0.4223	0.0004	0.0964	0.9441	0.0256	- 0.0412	0.0264**	0.0065	0.0088	1.0000	0.0150
Panama	- 0.2965	0.0351**	0.0331	- 0.1659	0.3094	0.0025	0.0634	0.5662	0.0003	-	-	-	-	-	-
Peru	0.2237	0.8897	0.0153	- 0.0363	0.2945	0.0030	- 0.0738	0.1795	0.0086	- 0.0771	0.0155**	0.0096	-	-	-
Venezuela	0.0637	0.7361	0.0041	- 0.2003	0.1997	0.0073	- 0.1752	0.1711	0.0092	- 0.0782	0.0204**	0.0098	- 0.0536	0.3162	0.0016

This table shows the results of the regression  $f(M) = \alpha + \beta D + \varepsilon$  where the dependent variable is the frequency of appearance of  $M$ -values and  $D$  is a dummy variable that takes the value 1 when the  $M$ -value is in the 98-02 interval and 0 otherwise. Test H0 (no barriers):  $\beta = 0$  vs. H1 (barriers are present):  $\beta < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

**Table 6** – Barrier Proximity Test: 95-05 Barrier

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>
Argentina	- 0.0014	0.4884	0.0000	0.0793	0.9664	0.0338	0.0684	0.9476	0.0266	- 0.0175	0.0282**	0.0039	- 0.0207	0.2684	0.0021
Brazil	0.0551	0.7359	0.0041	- 0.0599	0.4894	0.0001	0.0230	0.6844	0.0024	- 0.0021	0.3377	0.0002	0.0007	0.8754	0.0004
Chile	0.0680	0.9441	0.0256	0.0230	0.7023	0.0029	0.0791	0.9645	0.0329	0.1241	1.0000	0.2250	-	-	-
Colombia	0.0781	0.8869	0.0149	0.1727	0.9915	0.0566	0.0638	0.8120	0.0080	- 0.0217	0.0810*	0.0035	-	-	-
Mexico	- 0.0058	0.4356	0.0003	- 0.0010	0.4910	0.0000	0.0169	0.6548	0.0016	- 0.0435	0.0009***	0.0167	0.0002	0.5408	0.0000
Panama	- 0.2346	0.0196**	0.0427	- 0.1415	0.2711	0.0038	0.1024	0.6655	0.0015	-	-	-	-	-	-
Peru	- 0.0056	0.4826	0.0000	0.0035	0.5300	0.0001	- 0.0655	0.1210	0.0139	- 0.0649	0.0031***	0.0155	-	-	-
Venezuela	- 0.0127	0.4283	0.0003	- 0.0698	0.3369	0.0018	- 0.0689	0.2962	0.0029	- 0.0317	0.2135	0.0036	- 0.0544	0.2670	0.0027

This table shows the results of the regression  $f(M) = \alpha + \beta D + \varepsilon$  where the dependent variable is the frequency of appearance of  $M$ -values and  $D$  is a dummy variable that takes the value 1 when the  $M$ -value is in the 95-05 interval and 0 otherwise. Test H0 (no barriers):  $\beta = 0$  vs. H1 (barriers are present):  $\beta < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

**Table 7** – Barrier Proximity Test: 90-10 Barrier

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>
Argentina	0.0286	0.7887	0.0066	0.0780	0.9908	0.0553	0.0476	0.9289	0.0218	- 0.0051	0.2014	0.0008	0.0480	0.9451	0.0138
Brazil	0.1450	0.9141	0.0190	0.3314	0.7689	0.0055	0.0217	0.7223	0.0036	- 0.0016	0.3294	0.0002	0.0008	0.9667	0.0009
Chile	0.0428	0.9034	0.0172	- 0.0012	0.4860	0.0001	0.0704	0.9821	0.0442	0.0982	1.0000	0.3097	-	-	-
Colombia	0.0783	0.9433	0.0254	0.0568	0.8433	0.0104	0.0433	0.7829	0.0063	- 0.0464	0.0001***	0.0288	-	-	-
Mexico	0.0154	0.7137	0.0033	0.0199	0.7173	0.0034	0.0001	0.5012	0.0000	- 0.0381	0.0002***	0.0229	0.0108	1.0000	0.0158
Panama	- 0.2359	0.0033***	0.0731	- 0.2062	0.1232	0.0137	0.1919	0.8278	0.0091	-	-	-	-	-	-
Peru	0.0995	0.8454	0.0105	- 0.0139	0.3497	0.0015	- 0.0773	0.0354**	0.0329	0.1200	1.0000	0.0930	-	-	-
Venezuela	- 0.0048	0.4647	0.0001	- 0.0769	0.2728	0.0037	- 0.0982	0.1598	0.0101	0.0118	0.7273	0.0009	- 0.0568	0.1727	0.0062

This table shows the results of the regression  $f(M) = \alpha + \beta D + \varepsilon$  where the dependent variable is the frequency of appearance of  $M$ -values and  $D$  is a dummy variable that takes the value 1 when the  $M$ -value is in the 90-10 interval and 0 otherwise. Test H0 (no barriers):  $\beta = 0$  vs. H1 (barriers are present):  $\beta < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

**Table 8** – Barrier Proximity Test: 75-25 Barrier

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>	$\hat{\beta}$	$p$ -value	R <sup>2</sup>
Argentina	- 0.0014	0.4884	0.0000	0.0793	0.9664	0.0338	0.0684	0.9476	0.0266	- 0.0175	0.0282**	0.0039	- 0.0207	0.2684	0.0021
Brazil	0.0551	0.7359	0.0041	- 0.0599	0.4594	0.0001	0.0230	0.6844	0.0024	- 0.0021	0.3377	0.0002	0.0007	0.8754	0.0004
Chile	0.0680	0.9441	0.0256	0.0230	0.7023	0.0029	0.0791	0.9645	0.0329	0.1241	1.0000	0.2250	-	-	-
Colombia	0.0781	0.8869	0.0149	0.1727	0.9915	0.0566	0.0638	0.8120	0.0080	- 0.0217	0.0810*	0.0035	-	-	-
Mexico	- 0.0058	0.4356	0.0003	- 0.0010	0.4910	0.0000	0.0169	0.6548	0.0016	- 0.0435	0.0010***	0.0167	0.0002	0.5410	0.0000
Panama	- 0.2346	0.0196**	0.0427	- 0.1415	0.2711	0.0038	0.1024	0.6505	0.0015	-	-	-	-	-	-
Peru	- 0.0056	0.4826	0.0000	0.0035	0.5300	0.0001	- 0.0655	0.1210	0.0139	- 0.0649	0.3100	0.0155	-	-	-
Venezuela	- 0.0127	0.4283	0.0003	- 0.0698	0.3369	0.0018	- 0.0689	0.2962	0.0029	- 0.0317	0.1068	0.0036	- 0.0544	0.2670	0.0027

This table shows the results of the regression  $f(M) = \alpha + \beta D + \varepsilon$  where the dependent variable is the frequency of appearance of  $M$ -values and  $D$  is a dummy variable that takes the value 1 when the  $M$ -value is in the 75-25 interval and 0 otherwise. Test H0 (no barriers):  $\beta = 0$  vs. H1 (barriers are present):  $\beta < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

In general, we observe that the wider the interval, the more significant are the barriers. However, for instance, the difference in the number of barriers from the 90-10 interval to the 75-25 interval is not as extensive as we would expect to lead us to conclude that the existence of barriers is highly concentrated in the intervals between the strict barrier and the 90-10 mark. For M1000, we only detect a barrier in Brazil in the strict barrier within the four countries which allows us to study it. Nonetheless, the results would not be entirely reliable due to the low number of observations in that region. Furthermore, R-squared values are, overall, low which goes in accordance to previous studies like Bahng (2003). In our field of study, it is entirely plausible for the R-squared values to be low as we analyse human psychological behaviour.

#### **4.2.2 Barrier Hump Test**

The tests completed in the barrier hump test are mainly focused on the whole shape of the distribution rather than only on the  $M$ -values frequency distribution immediately around numbers. Under the null hypothesis of no barriers,  $\gamma$  should be zero, whereas, under the existence of barriers, there is a statistically significant negative relationship between  $f(M)$  and  $M^2$ .

Table 9 presents the details of our results. Panama shows the presence of psychological barriers in M0.1 following the previous results in the barrier proximity tests which gives us strong evidence to conclude with little doubt the existence of barriers. In addition, not only Panama but also Peru show evidence of barriers for M1 at 10% significance level. For M10, the null hypothesis of no barriers is also rejected for Peru and Venezuela at the 1% and 10% significance levels, respectively. For the M100, Argentina and Mexico exhibit robust evidence of barriers for all the significance levels as well. Finally, Argentina also presents evidence of barriers for M1000 which, curiously, does not follow the previous results in the barriers proximity tests.



**Table 9** – Barrier Hump Test

Series	M0.1 ( $l=0$ )			M1 ( $l=1$ )			M10 ( $l=2$ )			M100 ( $l=3$ )			M1000 ( $l=4$ )		
	$\hat{\gamma}$	$p$ -value	R <sup>2</sup>	$\hat{\gamma}$	$p$ -value	R <sup>2</sup>	$\hat{\gamma}$	$p$ -value	R <sup>2</sup>	$\hat{\gamma}$	$p$ -value	R <sup>2</sup>	$\hat{\gamma}$	$p$ -value	R <sup>2</sup>
Argentina	0.00000779	0.6550	0.0072	0.00002590	0.9212	0.0205	0.00005020	0.9983	0.1278	-0.00000014	0.0000***	0.0755	-0.00000925	0.0555*	0.0180
Brazil	0.00005250	0.8157	0.0100	0.00002540	0.5408	0.0023	0.00001320	0.7443	0.0104	0.00000151	0.6139	0.0011	0.00000000	0.8193	0.0017
Chile	0.00000728	0.6575	0.0246	-0.00001370	0.2256	0.0122	0.00002880	0.9495	0.1236	0.00000072	1.0000	0.5733	-	-	-
Colombia	0.00005301	0.8657	0.0157	0.00000922	0.6179	0.0187	0.00001290	0.6659	0.0245	-0.00000013	0.2571	0.0403	-	-	-
Mexico	-0.00000062	0.4836	0.0035	0.00002260	0.8863	0.0398	0.00000488	0.6073	0.0008	-0.00000069	0.0000***	0.0396	0.00000006	1.0000	0.0187
Panama	-0.00011300	0.0091***	0.0572	-0.00014800	0.0644*	0.0306	0.00015900	0.9469	0.2357	-	-	-	-	-	-
Peru	0.00001450	0.6059	0.0014	-0.00002920	0.0648*	0.0653	-0.00008510	0.0001***	0.1440	-0.00000014	0.3670	0.0680	-	-	-
Venezuela	-0.00000206	0.4724	0.0002	-0.00002290	0.3694	0.0400	-0.00006960	0.0980*	0.0255	-0.00000064	0.1454	0.0026	-0.00000316	0.3761	0.0095

This table shows the results of the regression  $f(M) = \alpha + \phi M + \gamma M^2 + \eta$  where the dependent variable is the frequency of appearance of  $M$ -values, minus 1 percentage point.  $M$  refers to the  $M$ -values between 00 and 99 (000 and 999 for the M100 and 0000 and 9999 for the M1000). Test H0 (no barriers):  $\gamma = 0$  vs. H1 (barriers are present):  $\gamma < 0$ . Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

### **4.3 Conditional Effects**

If psychological barriers in the indices do exist, we know that around those values the return series around and in the vicinity of these obstacles should register a pattern not found elsewhere. These tests focus on the approach of a barrier from below (possible resistance level) and from above (possible support level). In addition, the period after breaking a barrier is identically considered observing whether the markets calm down or are in turmoil.

For the 5 day period, Table 10 shows the mean return and variance equations. In the mean return equation, in all of the eight series tested, the coefficients estimates of AD are greater in magnitude than those of BD. Regarding an upward approach, the AU is higher than BU in magnitude only in Colombia and Panama. Of the remaining six, Argentina and Brazil are significantly higher at 1% significance level as well as Peru at 5% significance level. In the majority of the cases, the signal does not change after crossing a barrier meaning an increase in volatility right before and/or after crossing it.

Except for Venezuela, all the coefficients estimates of BD are negative meaning that the indices values may be struggling when trying to cross a barrier from above. Moreover, in Argentina and Peru, Chile and Colombia, this movement is at the 1%, 5% and 10% significance levels, respectively.

Regarding the results for the conditional variance equation, the GARCH term is significant, and the estimate is positive as expected, indicating significant GARCH effects. Interestingly, the GARCH term estimate is closer to one in Colombia, indicating a higher degree of volatility persistence. Furthermore, we must be aware that at a strict barrier, the variance indicators before and after crossing it should have different values indicating a possible agitated or quiet market. In our case, we find evidence in Colombia, Peru and Venezuela on a downward movement but with no statistical significance. However, concerning an upward movement, Brazil and Mexico present market turbulence right before crossing a barrier and the market calms down after it with statistical significance at 1% and 5% levels.

*Psychological Barriers in the Latin America's Stock Indices*

**Table 10** – Conditional Effects Summary 5 days: Return and Variance Equation - GARCH(1;1)

<b>Country</b> <b>Variable</b>	<b>Argentina</b>	<b>Brazil</b>	<b>Chile</b>	<b>Colombia</b>	<b>Mexico</b>	<b>Panama</b>	<b>Peru</b>	<b>Venezuela</b>
<b>Mean equation</b>								
C	0.1847 (0.0330)	0.0900 (0.021)	0.0651 (0.0116)	0.0381 (0.0217)	0.0961 (0.0135)	0.0940 (0.0263)	0.0778 (0.0140)	0.0939 (0.0168)
BD	- 0.8193 (0.1284)***	- 0.9022 (0.5731)	- 0.4138 (0.1699)**	- 0.3199 (0.1647)*	- 0.3065 (0.3311)	- 0.0760 (0.1602)	- 0.2749 (0.0971)***	0.0483 (0.1120)
AD	- 0.1982 (0.1411)	0.2813 (0.4025)	- 0.0611 (0.2296)	0.1512 (0.2336)	0.3823 (0.2209)*	0.0683 (0.1470)	- 0.0686 (0.0915)	0.0937 (0.1499)
BU	0.851167 (0.087)***	1.2110 (0.1533)***	- 0.0289 (0.1366)	0.0939 (0.1732)	0.1283 (0.2107)	- 0.0860 (0.1440)	0.2103 (0.1039)**	- 0.1042 (0.0894)
AU	0.5112 (0.0725)***	0.2103 (0.8250)	- 0.1264 (0.1927)	0.3165 (0.2038)	- 0.3970 (0.4270)	- 0.0753 (0.1436)	0.1063 (0.0915)	- 0.1680 (0.0762)**
<b>Variation equation</b>								
C	1.0180 (0.0244)	0.0671 (0.0082)	0.0307 (0.0039)	0.0736 (0.0109)	0.0253 (0.0025)	0.6329 (0.0395)	0.0723 (0.0047)	0.1886 (0.0062)
RESID(-1)^2	0.2872 (0.011)	0.0901 (0.0044)	0.1467 (0.0089)	0.1671 (0.0159)	0.0804 (0.0029)	0.1332 (0.0070)	0.1948 (0.0069)	0.2021 (0.0062)
GARCH(-1)	0.6465 (0.003)	0.8945 (0.0054)	0.8321 (0.092)	0.7679 (0.0194)	0.9098 (0.0034)	0.5673 (0.0263)	0.7808 (0.0059)	0.7593 (0.0061)
BD	- 0.7992 (0.094)***	- 0.0812 (0.4396)	- 0.0086 (0.0799)	- 0.0691 (0.0589)	0.0457 (0.1835)	- 0.3493 (0.0306)***	- 0.0459 (0.0398)	- 0.0489 (0.0586)
AD	- 0.1651 (0.1299)	- 0.1227 (0.4216)	0.0216 (0.0901)	0.2139 (0.1147)*	- 0.0117 (0.1778)	- 0.3157 (0.0419)***	- 0.0028 (0.0327)	0.0673 (0.0581)
BU	- 0.6658 (0.0331)***	- 0.8799 (0.0264)***	- 0.0812 (0.0558)	- 0.0603 (0.0879)	- 0.2706 (0.0545)***	- 0.3138 (0.0331)***	0.0892 (0.0431)**	- 0.1730 (0.0123)***
AU	- 0.9856 (0.0401)***	1.0484 (0.5803)*	0.1551 (0.0652)**	- 0.0015 (0.0803)	0.2324 (0.111)**	- 0.3084 (0.0424)***	- 0.0610 (0.0307)**	- 0.1046 (0.0230)***
<b>Starting period</b>	October 19 <sup>th</sup> , 1989	January 3 <sup>rd</sup> , 1994	September 27 <sup>th</sup> , 1987	January 14 <sup>th</sup> , 2008	January 4 <sup>th</sup> , 1988	January 1 <sup>st</sup> , 1992	January 2 <sup>nd</sup> , 1991	April 1 <sup>st</sup> , 1993
<b>N</b>	6835	5738	5809	2079	7303	6261	6521	5935

Table 10 shows the results of the mean and variance equation of a GARCH estimation of the form  $R_t = \beta_1 + \beta_2 BD_t + \beta_3 AD_t + \beta_4 BU_t + \beta_5 AU_t + \varepsilon_t$ ;  $\varepsilon_t \sim N(0, V_t)$ ;  $V_t = \alpha_1 + \alpha_2 BD_t + \alpha_3 AD_t + \alpha_4 BU_t + \alpha_5 AU_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$ . BD, AD, BU and AU are dummy variables. BD takes the value 1 in the 5 days before crossing a barrier on a downward movement and 0 otherwise whereas AD is for the 5 days after the same event. BU is for the 5 days before crossing a barrier from below, while AU is 1 in the 5 days after the same upward crossing.  $V_{t-1}$  refers to the moving average parameter and  $\varepsilon_{t-1}^2$  stands for the GARCH parameter. The  $l=3$  is tested for Brazil, Chile, Colombia and Mexico; the  $l=2$  for Argentina, Panama and Peru; the  $l=1$  for Venezuela. Robust standard error  $t$  statistics are beneath the coefficients in parentheses. Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*. The ending period is the same of all indices: December 31<sup>st</sup>, 2015.

For the 10 day period, Table 11 presents an outcome that reflects the importance of considering an extended time horizon. The coefficients estimates of AD are higher in terms of magnitude than BD for all countries except Venezuela which only presents one change. Nonetheless, in an upward movement, the AU is only higher than BU in Panama, and Chile whose result is statistically significant at 1% level.

Now, all the coefficients estimates of BD are negative meaning that for every index considered there is struggling before reaching a support level (downward movement) which emphasizes that, at least, until the 10 days prior to the barrier, there is still an erratic market movement with statistically significance level at 1% for a superior number of countries, namely Argentina, Chile, Panama and Peru. Also, Colombia and Mexico show the same effect but only for 5% and 10% significance level, respectively.

The results of a deep analysis of the conditional variance equation show a different pattern when compared to a 5 day period. Notwithstanding, Mexico presents the GARCH term estimate closer to one indicating a boiling point durability.

In a downward movement, we observe in Chile and Colombia turbulence before crossing a barrier and calm down after it. In the same trend, we find Mexico with a cool off after crossing a boundary at the 1% significance level. In Panama and Peru, we determine high levels of unpredictability both before and after crossing a barrier suggesting that the same strict barrier may represent not only a support but also a resistance level. On the upward side, Brazil exhibits a soaring volatility ahead of a barrier at the 1% significance level and a quiet movement right after it. Argentina and Venezuela sustain the same behaviour but statistical significant both before and after the barrier (1% and 5%). Peru shows an opposite effect at 1% significance level which emphasises the presence of support level. Lastly, Panama presents a fascinating result for highlighting a choppy trading activity in front and after crossing a barrier signalling a support and resistance level at 1% significance level.

*Psychological Barriers in the Latin America's Stock Indices*

**Table 11** – Conditional Effects Summary 10 days: Return and Variance Equation - GARCH(1;1)

<b>Country</b> <b>Variable</b>	<b>Argentina</b>	<b>Brazil</b>	<b>Chile</b>	<b>Colombia</b>	<b>Mexico</b>	<b>Panama</b>	<b>Peru</b>	<b>Venezuela</b>
<b>Mean equation</b>								
C	0.1199 (0.0244)	0.0866 (0.0215)	0.0672 (0.0117)	0.0423 (0.0221)	0.0942 (0.0136)	0.0538 (0.0068)	0.0782 (0.0145)	0.1015 (0.0171)
BD	- 0.4332 (0.1080)***	- 0.7201 (0.6791)	- 0.3203 (0.1007)***	- 0.2953 (0.1316)**	- 0.4498 (0.2581)*	- 0.1870 (0.0388)***	- 0.2960 (0.1109)***	- 0.0936 (0.0638)
AD	- 0.0575 (0.1073)	- 0.1084 (0.4758)	- 0.2922 (0.1254)**	- 0.0960 (0.1637)	0.1304 (0.1884)	0.0953 (0.0392)**	- 0.2204 (0.0838)***	- 0.0982 (0.0659)
BU	0.3066 (0.0952)***	0.4797 (0.2723)*	0.1782 (0.2131)	0.1721 (0.1458)	0.3990 (0.2133)*	- 0.0923 (0.0588)	0.1913 (0.0630)***	- 0.0316 (0.0771)
AU	- 0.0728 (0.1073)	0.0913 (0.3601)	0.3353 (0.1279)***	0.0375 (0.1444)	0.0236 (0.2231)	0.0698 (0.0600)	0.0141 (0.0574)	- 0.0918 (0.0993)
<b>Variation equation</b>								
C	0.0864 (0.0068)	0.0628 (0.0079)	0.0303 (0.0038)	0.0791 (0.0115)	0.0257 (0.0025)	0.3825 (0.0013)	0.0721 (0.0047)	0.1731 (0.0056)
RESID(-1)^2	0.1033 (0.0042)	0.0880 (0.0043)	0.1465 (0.0088)	0.1724 (0.0164)	0.0812 (0.0029)	0.5507 (0.0104)	0.1899 (0.0068)	0.1990 (0.0061)
GARCH(-1)	0.8858 (0.0039)	0.8977 (0.0052)	0.8324 (0.0092)	0.7576 (0.0200)	0.9088 (0.0034)	0.1230 (0.0022)	0.7854 (0.0059)	0.7708 (0.0058)
BD	0.0581 (0.0436)	- 0.0721 (0.2954)	- 0.0039 (0.0288)	- 0.0660 (0.0313)**	0.0671 (0.0774)	- 0.2529 (0.0140)***	0.0342 (0.0238)	- 0.1460 (0.0109)***
AD	- 0.0551 (0.0340)	- 0.0443 (0.2788)	0.0081 (0.0246)	0.1020 (0.0746)	- 0.1331 (0.0389)***	- 0.1233 (0.0142)***	- 0.0228 (0.0281)	- 0.1561 (0.0093)***
BU	- 0.0546 (0.0236)**	- 0.4272 (0.1528)***	0.0535 (0.0628)	- 0.0212 (0.0452)	- 0.0592 (0.0645)	- 0.2100 (0.0159)***	0.0017 (0.0173)	- 0.1085 (0.0100)***
AU	0.1070 (0.0212)***	0.4101 (0.2220)*	0.0701 (0.0685)	0.0344 (0.0424)	0.1263 (0.0786)	- 0.0810 (0.0183)***	- 0.0445 (0.0123)***	0.1240 (0.0184)***
<b>Starting period</b>	October 19 <sup>th</sup> , 1989	January 3 <sup>rd</sup> , 1994	September 27 <sup>th</sup> , 1987	January 14 <sup>th</sup> , 2008	January 4 <sup>th</sup> , 1988	January 1 <sup>st</sup> , 1992	January 2 <sup>nd</sup> , 1991	April 1 <sup>st</sup> , 1993
<b>N</b>	6835	5738	5809	2079	7303	6261	6521	5935

Table 11 shows the results of the mean and variance equation of a GARCH estimation of the form  $R_t = \beta_1 + \beta_2 BD_t + \beta_3 AD_t + \beta_4 BU_t + \beta_5 AU_t + \varepsilon_t$ ;  $\varepsilon_t \sim N(0, V_t)$ ;  $V_t = \alpha_1 + \alpha_2 BD_t + \alpha_3 AD_t + \alpha_4 BU_t + \alpha_5 AU_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$ . BD, AD, BU and AU are dummy variables. BD takes the value 1 in the 10 days before crossing a barrier on a downward movement and 0 otherwise whereas AD is for the 10 days after the same event. BU is for the 10 days before crossing a barrier from below, while AU is 1 in the 10 days after the same upward crossing.  $V_{t-1}$  refers to the moving average parameter and  $\varepsilon_{t-1}^2$  stands for the GARCH parameter. The  $l=3$  is tested for Brazil, Chile, Colombia and Mexico; the  $l=2$  for Argentina, Panama and Peru; the  $l=1$  for Venezuela. Robust standard error  $t$  statistics are beneath the coefficients in parentheses. Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*. The ending period is the same of all indices: December 31<sup>st</sup>, 2015.

#### **4.3.1 Conditional Effects Difference Tests**

Following the previous section by supposing the existence of barriers, when the index finally “breaks through” (whether on a downward or upward motion), a relaxation on the mean and variance should occur.

Table 12 contains the results of a 5 day period of the hypothesis listed in Section 3.2.5. We find no significant changes in the conditional mean returns after crossing a barrier in an upward movement which, by surprise, goes completely against the conclusions of Cyree *et al.* (1999) who analyses eight major stock indices around the globe (U.S., Canada, Europe and Asia). However, it goes along with the work of Aggarwal and Lucey (2007) in gold prices. Notably, Argentina and Panama present extremely high chi-square values statistically significance at 1% for all the events considered before approaching a barrier from below. It suggests an enormous volume of trading activity as the index price advances until finding a barrier.

In a downward movement, we expect “the difference in the conditional mean coefficients to be positive, since the expected sign before crossing is negative and the coefficient for after crossing is supposed to be negative and of a greater magnitude” as stated by Cyree *et al.* (1999, p. 81). We encounter statistically significant outcomes for Panama, Argentina and Mexico at 1%, 5% and 10%, respectively. Interestingly, all countries present the expected positive value in the difference of the conditional mean coefficients.

In terms of the conditional variance restriction tests, significant observable decreases are found in Colombia, Mexico and Panama subsequently a barrier is crossed as part of a downward movement. On the side of an upward movement, Argentina, Brazil, Mexico, Panama and Venezuela exhibit as well significant decreases in variance after crossing a barrier. The situations just described show evidence of psychological barriers as the market adopts the behaviour coincident with being in the vicinity of a barrier level. Actually, the volatility associated with the pre-crossing phase corresponds to the plausible event of technical trading immediately before a barrier.

For a 10 day period, we notice the same trend being followed meaning that an extension to a larger number of days analysed does not affect the previous conclusions as shown in

Table 13. Even so, it is relevant to note that Argentina and Panama present chi-square values more in line with the other countries.

**Table 12** – Conditional Difference Tests for Conditional Moments: 5 days

<b>Country</b> <b>Hypothesis</b>	<b>Argentina</b>	<b>Brazil</b>	<b>Chile</b>	<b>Colombia</b>	<b>Mexico</b>	<b>Panama</b>	<b>Peru</b>	<b>Venezuela</b>
<b>H1:</b> There is no significant difference in the conditional <u>mean return</u> before and after a <u>downwards</u> crossing of a barrier	956.56 (0.0000)***	2.26 (0.1328)	2.17 (0.1404)	2.96 (0.0851)*	2.98 (0.0843)*	37.71 (0.0000)***	2.24 (0.1345)	0.06 (0.8065)
<b>H2:</b> There is no significant difference in the difference in conditional <u>mean return</u> before and after an <u>upwards</u> crossing of a barrier	961.10 (0.0000)***	3.76 (0.0525)*	0.14 (0.7083)	0.70 (0.4028)	1.96 (0.1615)	1919.63 (0.0000)***	0.58 (0.4463)	0.30 (0.5839)
<b>H3:</b> There is no significant difference in the difference in conditional <u>variance</u> before and after a <u>downwards</u> crossing of a barrier	965.08 (0.0000)***	4.92 (0.0265)**	0.08 (0.7773)	3.83 (0.0503)*	0.02 (0.8875)	1496.97 (0.0000)***	0.34 (0.5598)	0.5 (0.4795)
<b>H4:</b> There is no significant difference in the difference in conditional <u>variance</u> before and after an <u>upwards</u> crossing of a barrier.	964.30 (0.0000)***	11.12 (0.0009)***	2.84 (0.0918)*	0.19 (0.6629)	7.86 (0.0051)***	280.84 (0.0000)***	2.92 (0.0875)*	1.06 (0.3032)

Table 12 shows the result of Chi-squared values (based on the likelihood ratio test) on coefficients for each index for differences from before to after crossing a psychological barrier in a downward and upward movement. Note: p-values are in parentheses. Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.



*Psychological Barriers in the Latin America's Stock Indices*

**Table 13** – Conditional Difference Tests for Conditional Moments: 10 days

<b>Hypothesis</b>	<b>Argentina</b>	<b>Brazil</b>	<b>Chile</b>	<b>Colombia</b>	<b>Mexico</b>	<b>Panama</b>	<b>Peru</b>	<b>Venezuela</b>
<b>H1:</b> There is no significant difference in the conditional <u>mean return</u> before and after a <u>downwards</u> crossing of a barrier	6.14 (0.0132)**	0.64 (0.4237)	0.04 (0.8415)	0.98 (0.3222)	3.36 (0.0668)*	7.66 (0.0056)***	0.38 (0.5376)	0.03 (0.8625)
<b>H2:</b> There is no significant difference in the difference in conditional <u>mean return</u> before and after an <u>upwards</u> crossing of a barrier	7.66 (0.0056)***	0.72 (0.3961)	0.36 (0.5485)	0.466 (0.4948)	1.64 (0.2003)	2.99 (0.0838)*	4.66 (0.0309)**	0.30 (0.5839)
<b>H3:</b> There is no significant difference in the difference in conditional <u>variance</u> before and after a <u>downwards</u> crossing of a barrier	1.84 (0.1750)	0.02 (0.8875)	0.10 (0.7518)	4.074 (0.0435)**	2.86 (0.0908)*	6.16 (0.0131)**	0.76 (0.3833)	0.12 (0.7290)
<b>H4:</b> There is no significant difference in the difference in conditional <u>variance</u> before and after an <u>upwards</u> crossing of a barrier.	3.44 (0.0636)*	3.98 (0.0460)**	0.01 (0.9203)	0.55 (0.4583)	3.50 (0.0614)*	4.43 (0.0353)**	2.44 (0.1183)	17.50 (0.0000)***

Table 13 shows the result of Chi-squared values (based on the likelihood ratio test) on coefficients for each index for differences from before to after crossing a psychological barrier in a downward and upward movement. Note: p-values are in parentheses. Significance at the 1%, 5% and 10% levels are denoted respectively \*\*\*, \*\*, \*.

## **5. Conclusion**

The objective of this dissertation has been to further document and examine whether psychological barriers exist in the major stock indices of Latin America countries including Argentina, Brazil, Chile, Colombia, Mexico, Panama, Peru, and Venezuela. To the best of our knowledge, this study has been the first to examine the existence of psychological barriers in the Latin America's stock indices giving us the opportunity to fill this gap in the financial literature.

Firstly, we performed a uniformity test to confirm that the null hypothesis is rejected in all the indices used. Secondly, a barrier proximity test was conducted in several intervals around possible barriers and the results showed that there is a tendency to increase the number of statistically significant barriers as we keep widening the region analysed. However, the number of barriers found only presented a mere increase from the 90-10 mark which tells us that the existence of obstacles is more frequent around narrow intervals. Thirdly, a test focused on the whole shape of the distribution was carried out, called barrier hump test, reinforcing the conclusion obtained in the barrier proximity test. Fourthly, the conditional effects were executed, assuming the existence of barriers, to see if a different market behaviour happened around round numbers. Both for 5 and 10 days, we observed more market turbulence right before a downward, and an upward movement in all the countries studied. Finally, the conditional effect difference tests were conducted and the results were quite surprising. For the 5 days, we found no significant changes in the conditional mean returns after crossing a barrier from below as opposed to other studies in stock indices seems to present like Cyree et al. (1999). Concerning the conditional variance, Mexico and Panama are the only countries where we perceived significant decreases after crossing a barrier both from below and above. Regarding the 10 day period, it was noticeable the same trend meaning an extension to a larger number of days analysed did not affect the previous conclusions.

The primary findings of the study suggest the existence of psychological barriers in the main indices of each of these countries: Argentina, Mexico, Panama and Peru. On the other hand, Brazil, Colombia and Venezuela show inconclusive results. In reality, looking for the graph of each index, it seems to present some barriers at different values. However, the tests do not clearly confirm that. In Chile, there is no evidence of barriers at all. In all

countries, we do find that the numbers do not follow the so called “random walk theory” which is consistent with the results presented by authors such as Lo and MacKinlay (1988) and Jegadeesh (1990). Thus, our research seems to suggest the possibility of using an investment strategy based on this phenomena.

The conclusion of our study may be used by investors to take advantage in their trading sessions. Some initial studies such as De Grauwe and Decupere (1992) and Donaldson and Kim (1993) appear to have already influenced investors' decisions in the U.S. and Europe equities. However, our data seems not to be affected since their publications.

We have several suggestions for future search: to begin with, we were not able to get the available data for all the stock indices since their formation meaning that more years could have been exploited. Another aspect to be considered is the reasonable increase in the number of Latin America countries studied as there is a tendency, in the long-run, for nations to present positive economic growth, so we expect that the ones not included in our dissertation to gain relevance in the future. Besides, the use of other methodologies like Benford's law, firstly explored by De Ceuster et al. (1998), would also be productive. Moreover, it could be interesting to determine how investors switch between fundamentally-driven behaviour and psychologically-influenced behaviour. Finally, we highly recommend the investigation concerning individual stocks of the same geographical area since there is no priori study on that matter, as far as we know.

## **References**

- Aggarwal, R. and Lucey, B. M. (2007), "Psychological barriers in gold prices?", *Review of Financial Economics*, Vol. 16, No. 2, pp. 217-230.
- Bahng, S. (2003), "Do psychological barriers exist in the stock price indices? Evidence from Asia's emerging markets", *International Area Review*, Vol. 6, No. 1.
- Bertola G. and Caballero, R. J. (1992), "Target Zones and Realignments", *The American Economic Review*, Vol. 82, No. 3, pp. 520-536.
- Brenner, G. A. and Brenner, R. (1982), "Memory and Markets, or Why Are You Paying \$2.99 for a Widget?", *The Journal of Business*, Vol. 55, No. 1, pp. 147-158.
- Brock, W., Lakonishok, J. and LeBaron, B. (1992), "Simple technical trading rules and the stochastic properties of stock returns", *The Journal of Finance*, Vol. 47, No. 5, pp. 1731 – 1765.
- Burke, S. (2001), "Barriers in US benchmark Bonds Yields", Working paper, Faculty of Commerce and Business Administration, The University of British Columbia, Vancouver, Canada.
- Chen, M. H. and Tai, V. W. (2011), "Psychological barriers and prices behaviour of TAIEX futures", *Global Economy and Finance Journal*, Vol. 4, No. 2, pp. 1-12.
- Cooney, J. J. W., Van Ness, B. and Van Ness, R. (2003), "Do investors prefer even-eighth prices? Evidence from NYSE limit orders", *Journal of Banking and Finance*, Vol. 27, No. 4, pp. 719-748.
- Cyree, K. B., Domian, D. L., Louton, D. A. and Yobaccio, E. J. (1999), "Evidence of psychological barriers in the conditional moments of major world stock indices", *Review of Financial Economics*, Vol. 8, No. 1, pp. 73-91.
- De Ceuster, M. J. K., Schatteman, T. and Dhaene, G. (1998), "On the hypothesis of psychological barriers in stock markets and Benford's Law", *Journal of Empirical Finance*, Vol. 5, No. 3, pp. 263-279.
- De Grauwe, P. and Decupere, D. (1992), "Psychological barriers in the foreign exchange markets", *Journal of International and Comparative Economics*, Vol. 9, No. 1, pp. 87-101.
- Donaldson (1990), "Psychological barriers in asset prices, rationality and the efficient market hypothesis", *Princeton financial research memorandum*, Vol. 114.

- Donaldson, R. G. and Kim, H. Y. (1993), "Price Barriers in the Dow Jones Industrial Average", *Journal of Financial & Quantitative Analysis*, Vol. 28, No. 3, pp. 313-330.
- Dorffleitner, G. and Klein, C. (2009), "Psychological barriers in European stock markets: Where are they?", *Global Finance Journal*, Vol. 19, No. 3, pp. 268-285.
- Dowling, M., Cummins, M. and Lucey, B. M. (2016), "Psychological barriers in oil futures markets", *Energy Economics*, Vol. 53, pp. 293-304.
- Fama, E. F. (1970), "Efficient Capital Markets: a Review of Theory and Empirical Work", *The Journal of Finance*, Vol. 25, No. 2, pp. 383-417.
- Feng, L. and Seasholes, M. S. (2005), "Do Investor Sophistication and Trading Experience Eliminate Behavioral Biases in Financial Markets?", *Review of Finance*, Vol. 9, No. 3, pp. 305-351.
- Folkertsma, C. K. (2002), "The euro and psychological prices: Simulations of the worst-case scenario", *De Economist*, Vol. 150, No. 1, pp. 19-40.
- Friedman, L. (1967), "Psychological pricing in the food industry", *Prices: Issues in Theory, Practice, and Public Policy*. University of Pennsylvania Press, Philadelphia, pp. 187-201.
- Hirshleifer, D. (2001), "Investor Psychology and Asset Pricing", *The Journal of Finance*, Vol. 56, No. 4, pp. 1533-1597.
- Holdershaw, J., Gendall, P. and Garland, R. (1997), "The widespread use of odd pricing in the retail sector", *Marketing Bulletin 7 - Department Of Marketing Massey University*, Vol. 8, pp. 53-58.
- Hornik, J., Cherian, J. and Zakay, D. (1994), "The influence of prototypic values on the validity of studies using time estimates", *Journal of the Market Research Society*, Vol. 36, No. 2, pp. 145-147.
- Jang, B. G., Kim, C., Kim, K. T., Lee, S. and Shin, D. H. (2015), "Psychological Barriers and Option Pricing", *Journal of Futures Markets*, Vol. 35, No. 1, pp. 52-74.
- Jegadeesh, N. (1990), "Evidence of Predictable Behavior of Security Returns", *The Journal of Finance*, Vol. 45, No. 3, pp. 881-898.
- Kashyap, A. K. (1995), "Sticky Prices: New evidence from retail catalogs", *Quarterly Journal of Economics*, Vol. 110, No. 1, pp. 245-274.

- Koedijk, K. G. and Stork, P. A. (1994), "Should we care? psychological barriers in stock markets", *Economics Letters*, Vol. 44, No. 4, pp. 427-432.
- Ley, E. and Varian, H. R. (1994), "Are there psychological barriers in the Dow-Jones index?", *Applied Financial Economics*, Vol. 4, No. 3, pp. 217-224.
- Lo, A. W. and Mackinlay, A. C. (1988), "Stock Market Prices do not Follow Random Walks: Evidence from a Simple Specification Test", *The Review of Financial Studies*, Vol. 1, No. 1, pp. 41-66.
- Lu, O. F. and Giles, D. E. (2010), "Benford's law and psychological barriers in certain eBay auctions", *Applied Economics Letters*, Vol. 17, No. 10, pp. 1005-1008.
- Lucey, M. E. and O'Connor, F. A. (2016), "Mind the gap: Psychological barriers in gold and silver prices", *Finance Research Letters*, Vol. 17, pp. 135-140.
- Mitchell, J. (2001), "Clustering and psychological barriers: The importance of numbers", *Journal of Futures Markets*, Vol. 21, No. 5, pp. 395- 428.
- Mitchell, J. and Izan, H. Y. (2006), "Clustering and psychological barriers in exchange rates", *Journal of International Financial Markets, Institutions & Money*, Vol. 16, No. 4, pp. 318-344.
- Niederhoffer, V. (1965a), "Clustering of stock prices", *Operations Research*, Vol. 13, No. 2, pp. 258-265.
- Niederhoffer, V. (1965b), "A New Look at Clustering of Stock Prices", *The Journal of Business*, Vol. 39, No. 2, pp. 309-313.
- Osborne, M. F. M. (1962), "Periodic Structure in the Brownian Motion of Stock Prices", *Operations Research*, Vol. 10, No. 3, pp. 345-379.
- Palmon, O., Smith, B. A. and Sopranzetti, B. J. (2004), "Clustering in real estate prices: Determinants and consequences", *Journal of Real Estate Research*, Vol. 26, No. 2, pp. 115-136.
- Preece, D. A. (1981), "Distributions of Final Digits in Data", *Journal of the Royal Statistical Society. Series D (The Statistician)*, Vol. 30, No. 1, pp. 31-60.
- Reuters (2010), "Chile stock index closes at record high near 5,000", <http://uk.reuters.com/article/markets-chile-stocks-idUKN0224029320101102>, accessed in May 13<sup>th</sup>, 2017.

- Reuters (2012), "Latam stocks boosted by Spain plan, Brazil dips", [http://www.reuters.com/article/markets-latam-stocks](http://www.reuters.com/article/markets-latam-stocks/idUSL1E8KRDOR20120927)  
idUSL1E8KRDOR20120927, accessed in May 13<sup>th</sup>, 2017.
- Schindler, R. M. and Kirby, P. N. (1997), "Patterns of Rightmost Digits Used in Advertised Prices: Implications for Nine-Ending Effects", *Journal of Consumer Research*, Vol. 24, No. 2, pp. 192-201.
- Schwartz, A. L., Van Ness, B. F. and Van Ness, R. A. (2004), "Clustering in the futures market: Evidence from S&P 500 futures contracts", *Journal of Futures Markets*, Vol. 24, No. 5, pp. 413-428.
- Shawn, L. K. J. and Kalaichelvan, M. (2012), "A critical evaluation of the significance of round numbers in European equity markets in light of the predictions from Benford's law", *International Research Journal of Finance and Economics*, Vol. 95, pp. 196-210.
- Shiller, R. J. (1988), "Fashions, fads and bubbles in financial markets", *Oxford, England: Oxford University Press*, pp. 56-68.
- Shleifer, A. and Vishny, R. W. (1997), "The limits of arbitrage", *The Journal of Finance*, Vol. 52, No. 1, pp. 35-55.
- Simon, H. A. (1955), "A behavioral model of rational choice", *The Quarterly Journal of Economics*, Vol. 69, No. 1, pp. 99-118.
- Sonnemans, J. (2006), "Price clustering and natural resistance points in the Dutch stock market: A natural experiment", *European Economic Review*, Vol. 50, No. 8, pp. 1937-1950.
- Stiving, M. and Winer, R. S. (1997), "An empirical analysis of price endings with scanner data", *Journal of Consumer Research*, Vol. 24, No. 1, pp. 57-67.
- Tversky, A. and Kahneman, D. (1974), "Judgment under uncertainty: Heuristics and biases", *Science*, Vol. 185, No. 4157, pp. 1124-1131.
- Westerhoff, F. (2003), "Anchoring and Psychological Barriers in Foreign Exchange Markets", *Journal of Behavioral Finance*, Vol. 4, No. 2, pp. 65-70.
- Woodhouse, S. A., Singh, H., Bhattacharya, S. and Kumar, K. (2016), "Invisible walls: Do psychological barriers really exist in stock index levels?", *North American Journal of Economics and Finance*, Vol. 36, pp. 267-278.